MULTI-RESOLUTION COLOR CONTACT-TYPE IMAGE SENSING APPARATUS

FIELD OF INVENTION

This invention relates to a multi-resolution color contact-type image sensing apparatus which uses arranged segments of varying pixel density along an array of photosensors. A color image of an original is thereby obtained with a particular resolution from a certain sized original which is exposed to the full array. A higher resolution image is obtained from a smaller sized original which is exposed to a portion of the array having segments with higher densities.

BACKGROUND OF THE INVENTION

Current color contact-type image sensor devices employ segments of linearly arrayed photosensors produced in silicon and wire bonded as a chip-on-board construction. Each segment is similar or identical in pixel element density. The segments are arranged to span the maximum width of the original image to be scanned. Color images are produced by time-multiplexing illumination produced from at least three different types or colors of LEDs (i.e. red, green, and blue). A self-focusing lens system is arranged to focus the illuminated image on the photosensor pixel elements as the image is mechanically moved across the length of the linear photosensor array.

In order to produce multiple resolution images from the same array, optical elements are required to provide different magnifications of the image onto the photosensor elements. To produce a higher resolution resulting image, an original image of fixed sized must be magnified and focused across a larger number of photosensor elements. Hence, the sensing element ratio must approximately scale with the inverse size ratio of the original image. This multi-resolution sensor and lens configuration is relatively costly to manufacture.

What is needed is an image sensing apparatus which provides multi-resolution color capabilities, but without requiring a complicated lens configuration for magnification. The apparatus should be capable of producing high resolution resulting images from original images which are smaller in size than the full width of the photosensor array. The system should be a relatively compact and economical device to manufacture and use.

SUMMARY OF THE INVENTION

The invention described herein comprises the geometric layout and use of a sensor array constructed to be able to yield multiple resolution resulting images from different sized original images. Prior sensor arrays have been comprised of a linear array of photosensor segments, with each segment having a similar pixel density. A dual-resolution embodiment of the present invention includes central segments which have a higher density of photosensitive pixel elements than the peripheral segments. A triple-resolution embodiment includes a third set of middle photosensor segments which have a higher pixel density than the central segments. These segments of varying pixel density can be aligned in a linear arrangement or staggered in a step-wise arrangement. A standard resolution resulting image can be produced from an original which spans the entire width of the photosensor segments. A higher resolution resulting image can be produced from an original which has been sized to pass over the appropriate middle or central segments, depending upon the resolution desired.

One advantage of the disclosed invention is that the photosensor array is relatively inexpensive and easy to manufacture. The resulting device is also relatively compact and can be used in color contact-type image sensing applications (i.e. a one-to-one ratio between photosensor elements and the scanned image). Other advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings which set forth, by way of illustration and example, certain embodiments of this invention. The drawings constitute a part of this specification and include exemplary embodiments, objects and features of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1(a) shows a photosensor array segment from the sensor board shown in FIG. 1(b).

FIG. 1(b) shows a prior art color contact-type image sensor board.

FIG. 2(a) shows a peripheral photosensor array segment from the dual-resolution sensor board of FIG. 2(c).

FIG. 2(b) shows a central photosensor array segment from the dual-resolution sensor board of FIG. 2(c).

FIG. 2(c) shows an example dual-resolution color contact-type image sensor board.

FIG. 3(a) shows a peripheral photosensor array segment from the triple-resolution sensor board of FIG. 3(e).

FIG. 3(b) shows a middle photosensor array segment from the triple-resolution sensor board of FIG. 3(e).

FIG. 3(c) shows a central photosensor array segment from the triple-resolution sensor board of FIG. 3(e).

FIG. 3(d) shows an alternative central photosensor array segment from the triple-resolution sensor board of FIG. 3(e).

FIG. 3(e) shows an example triple-resolution color contact-type image sensor board.

FIG. 4(a) shows a peripheral photosensor array segment from the triple-resolution sensor board of FIG. 4(d).

FIG. 4(b) shows a middle photosensor array segment from the triple-resolution sensor board of FIG. 4(d).

FIG. 4(c) shows a central photosensor array segment from the triple-resolution sensor board of FIG. 4(d).

FIG. 4(d) shows yet another example of a triple-resolution color contact-type image sensor board.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1(a)–1(b) collectively show a simplified view of a prior art photosensor board 10 as used in color contact-type image sensors. The photosensor array 12 typically consists of a collection of linearly aligned photosensor segments 14 produced in silicon and bonded, via wire bonds 16 and the like, to the printed circuit board 18 as a chip-on-board construction. In this instance, each segment 14 is identically formed and includes a certain number N of pixels 20, which are shown numbered 1 to N. Accordingly, in order for smaller sized originals to be scanned at a higher resolution, the image must be magnified via a lens arrangement (not shown) to cover more pixels. Such lens arrangements are relatively expensive to produce.

FIGS. 2(a)–2(c) collectively show a simplified view of the geometry of an embodiment of the present invention. A dual-resolution photosensor array 30 is shown in FIG. 2(c) comprised of linearly aligned photosensor segments 32. As before, the photosensor segments might be produced in silicon and bonded, via wire bonds 40 and the like, to the printed circuit board 42 as a chip-on-board construction. In this example embodiment, a central portion 34 of the pho-

tosensor segments 32 have a relatively higher pixel density. The peripheral segments 36, shown enlarged in FIG. 2(a), are comprised of a certain number N of pixels, shown numbered as 1_p to N_p. The central segments 38 are shown enlarged in FIG. 2(b). Each peripheral pixel 44 corresponds in width with a two-by-two (2×2) grouping or arrangement of central pixels 45, as depicted by the arrows 46. Each central segment 38 thereby has central pixels 45 which are four times (4×) as numerous as the peripheral pixels 44, and shown numbered as 1_c to $2N_c$ across the top row, and $2N_c+1$ to $4N_c$ across the bottom row. This 4× density of the central segments 38, as compared to the peripheral segments 36, is shown for example purposes only and any density might be used within the scope of the invention.

With the shown sensor geometry, the entire width of an original image can be scanned across the photosensor array 32 at one base resolution, or a smaller sized original image can be scanned across the central portion 34 to produce a higher density resulting image. The mechanical movement used between the sensor and the original image could have the same step size for either resolution used. In order to compensate for the smaller pixel area available in the central portion 34, a variety of solutions exist including, but not limited to: additional amplification of the signal produced by the central segments; increasing the light integration time; increasing the illumination level; or some combination thereof. It is also preferable, in order to provide a more economical device, to utilize the same circuitry to receive the electrical signals representative of the image data for processing either resolution image. A control signal would be provided, either manually or automatically, to select whether the whole width is to be active, or just the central portion 34. When the whole width is active, the signals from the 2×2 central grouping of pixels might, for instance, be summed to yield a signal roughly equivalent to the signal produced by one peripheral pixel.

FIGS. 3(a)–3(e) collectively show a simplified view of the geometry of yet another embodiment of the present invention. A triple-resolution photosensor array 50 is shown in FIG. 3(e) comprised of three types of linearly aligned photosensor segments 52, namely peripheral 58, middle 60, and central segments 62 (or 64), with each segment type having different relative pixel densities. The photosensor segments might be produced, as described above, in silicon and bonded, via wire bonds 54 and the like, to the printed circuit board 56 as a chip-on-board construction. In this example embodiment, a middle portion 66 of the photosensor segments 52 has a relatively higher pixel density than the peripheral segments 59, and a central portion 68 of the photosensor segments 52 has a relatively higher pixel density than the middle segments 60.

A peripheral segment 58 is shown in FIG. 3(a) with a certain number N of pixels 59 numbered as 1_p to N_p. A middle segment 60 is shown in FIG. 3(b) with a relatively higher number of middle pixels 61. In this instance, a peripheral pixel 59 corresponds in width with a 2×2 grouping of middle pixels 61, as depicted by arrows 66. The middle pixels 61 are shown numbered as 1_M to $2N_M$ and $2N_M+1$ to $4N_M$ across the adjoining rows of pixels for this example configuration. One embodiment of a central segment 62 is shown in FIG. 3(c), wherein each middle pixel 61 corresponds in width with two staggered central pixels 63, as depicted by arrows 68. Yet another embodiment of a central segment 64 is shown in FIG. 3(d) wherein each middle pixel 61 corresponds in width with a grouping of two aligned central pixels 65, as depicted by arrows 70. In each embodiment, the staggered and aligned central pixels 63, 65

are numbered as 1_c to $4N_c$ and $4N_c+1$ to $8N_c$ across the upper and lower rows of pixels. These example arrangements for the central segments 62, 64 provide yet another factor of 2 increase in resolution over the middle segments 60.

With this representative sensor geometry, an original image which spans the whole width of the photosensor array 52 could be imaged at a certain base resolution, the middle portion 66 and central portion 68 together could be used to scan an image at twice (or double) the base resolution, and the central portion 68 could be used to scan an image at four times (or quadruple) the base resolution. With the geometry shown, the mechanical movement between the sensor array 52 and the original image might use the same step size for both the base resolution and the double resolution scanning processes. The step size would likely be halved for the quadruple resolution scanning process.

With three different resolutions available for processing three differently sized original input images, similar compensation solutions for the pixel area differences could be provided as previously described above for the dual-resolution embodiment. With this particular sensor example, a control signal, either manual or automatic, would select whether just the central portion 68 is to be used, or whether the middle and central portions 66 and 68 are to be used, or whether the whole width is to be active. When the combined middle and central regions 66, 68 are used, the signals from the two of the central pixels 63 or 65 could be summed and doubled to yield a signal roughly equivalent to that from one middle pixel 61. When the whole width is be active, the signals from a 2×2 grouping of middle pixels 61 could be summed to yield a signal roughly equivalent to that coming from one peripheral pixel 59. Alternatively and as appropriate, the signals derived as stated above from a grouping of two central pixels could take the place of one middle pixel and thereby be summed to yield a signal roughly equivalent to that coming from one perhiperial pixel 59.

FIGS. 4(a)–4(d) collectively show a simplied view of the geometry of still another embodiment of the present invention. A triple-resolution photosensor array 80 is shown in FIG. 4(d) comprised of three levels 110–112 of linearly aligned photosensor segments, respectively comprised of peripherial segments 82, middle segments 84, and central segments 86, with each segment type having different relative pixel densities. The photosensor segments might be produced, as described above, in silicon and bonded, via wire bonds 88 and the like, to the printed circuit board 90 as a chip-on-board construction. In this example embodiment, the middle portion 92 of the photosensor segments 84 have a relatively higher pixel density than the peripherial segments 82, and the central portion 94 of the photosensor segments 86 have a relatively higher pixel density than the middle segments 84.

As similar to FIG. 3, a peripherial segment 82 is shown in FIG. 4(a) with a certain number N of pixels 96 numbered as 1_p to N_p. A middle segment 84 is shown in FIG. 4(b) with a relatively higher number of middle pixels 98. In this instance, a peripherial pixel 96 corresponds in width with a grouping of 2×2 middle pixels 98, as depicted by arrows 102. The middle pixels 98 are shown numbered as 1_M to $2N_M$ and $2N_M+1$ to $4N_M$ across the adjoining rows of pixels for this example configuration. This embodiment shows a central segment 86 in FIG. 4 (c), wherein each middle pixel 98 corresponds in width with a grouping of two aligned central pixels 100, as depicted by arrows 104. The aligned central pixels 100 are numbered as 1_c to $4N_c$ and $4N_c+1$ to